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THE SO-CALLED MONSOONAL WINDS OF TEXAS

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The attention of early students of the wind systems of the United States was soon drawn to the seasonal change in direction of the winds of certain localities. Blodget[6] was among the first to point out this characteristic. He says, discussing the winds of the Gulf of Mexico and adjacent regions:

> Westward of New Orleans they [the winds] are much stronger and more nearly continuous than eastward, and on the coast of southwestern Texas they develop something very near a monsoon, as the term is used and understood in discussing the climate of the Eastern Hemisphere.

The late Prof. Mark Harrington discussed the subject in a paper presented before the Philosophical Society of Washington in 1894, under the title "The Texas Monsoons."[7]

A careful reading of Harrington's paper discloses the fact that he classed as monsoon winds all of those which had a more or less well-marked seasonal change in direction from land to sea and vice versa. Thus, he indicated six different regions in the United States which according to his concept were characterized by monsoon winds. His ideas were apparently not very definite, since he uses the term "periodic winds" interchangeably with "monsoon" winds.

The regions he so classed are as follows:

1. The Texas monsoons, extending up the plains sometimes beyond the limits of Texas and even to the northern boundary of the United States.
2. California monsoons, occurring on the Pacific coast south of San Francisco and reaching up the Sacramento and San Joaquin valleys.
3. The Willamette and Puget Sound periodic winds.
4. The northeast and southwest winds of the Atlantic coast.
5. The offshore winds above Cape Henry.
6. Isolated cases at Escanaba, Duluth, Las Animas, and Winnemucca.

A more rational classification of these winds would assign them as members of the general atmospheric circulation in the zone of prevailing westerly winds. These winds owe their seasonal change partly to local and partly to general causes and should not be confused with the monsoon winds of southern and southeastern Asia.

It may be said on behalf of the earlier writers that they were not in possession of adequate data. Nevertheless, Ferrel, than whom no other was better qualified to analyze the physical causes which produce monsoon winds, carefully avoided classifying the winds of any portion of the United States as monsoonal. He says:[8]

> On the continent of North America we have monsoon influences similar to those of Asia, but not nearly so strong, because the extent of the continent and, consequently, the annual range of temperature is not so great. They are, for the most part, not sufficiently strong to completely overcome and reverse the current of the general circulation of the atmosphere and so to produce a real monsoon, but they cause great differences between the prevailing direction of the winter and summer winds.

The word "monsoon" is from the Arabic, meaning "a time, or season." It may be defined as a term which is used to designate certain winds which blow with great persistence and regularity in opposite directions at different seasons of the year. In its true sense it is applied only to those great systems of inflowing and outflowing winds which so greatly modify the climate of southern and southeastern Asia. Professor Ward[9] recognizes this fact and has stated in his discussion of the winds of the United States that monsoon winds in the Indian sense do not occur in the United Sattes.

THE SURFACE WINDS OF TEXAS

The records of the Weather Bureau station at Galveston, Tex., have been used as the most representative station on the Texas coast. The prevailing direction of the wind at that station as compiled by Section Director L. H. Murdoch, and published in Weather Bureau Bulletin Q—Climatology of the United States, page 437—is from the southeast in all months of the year, except June, July, and August, when it is from the south. The accuracy of this record, which is based on eye observations made bidaily and for a time tridaily, may be checked by a comparison with results based on hourly observations as given by automatically recording instruments. Such a record based on a 5-year average is printed in the Annual Report of the Chief of Weather Bureau, 1896–97, page 115. From it the data of Table 1 have been obtained.

TABLE 1.—*Average duration of wind in hours, from each of the eight principal points of the compass, Galveston, Tex., for the five years 1891–1895*

[From Annual Report Chief Weather Bureau, 1896–97, p. 115]

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual
N	92	94	82	43	49	18	12	25	39	70	74	89	688
S	108	105	124	185	232	**229**	**258**	**195**	102	78	118	136	1,865
NE	105	107	105	48	77	47	34	59	152	163	106	92	1,094
SW	61	50	65	50	71	117	233	193	35	61	86	70	1,092
E	70	80	57	53	30	43	27	44	103	97	105	66	776
W	27	21	12	17	5	27	23	54	6	17	27	33	269
SE	**157**	**144**	**240**	**290**	**250**	223	136	131	**258**	**205**	**122**	**160**	**2,318**
NW	111	72	58	33	29	15	26	40	21	48	79	96	627

The data of the above table have been arranged in pairs of contrasted directions for ease of comparison.

The prevailing direction for each month is shown by the figures in bold-faced type, and it is seen at once that in every case the prevailing direction as obtained from eye observations is confirmed; it is also seen that the duration of south winds is nearly three times as great as for north winds; this proportion also holds in the case of east and west winds and southeast and northwest winds. The latter stand in the greatest contrast to each other among all the pairs of wind directions.

In no case is there what can be called a distinct reversal of the surface wind direction in the sense that the great seasonal increase in southerly winds is associated with a correspondingly great increase in the northerly winds of winter.

FREE AIR WINDS OVER TEXAS AND TO THE NORTH

For a number of years it has been a matter of common knowledge among the Washington forecasters that at

[6] Blodget's Climatology of the U. S. 1857, p. 364.
[7] Philosophical Society of Washington Bull. Vol. XII, pp. 293–308.
[8] W. Ferrel, A popular treatise of the winds, p. 214.
[9] Ward, R. DeC., Annals, Association Amer. Geographers, 1916, p. 111.

times a high current from the southwest, as evidenced by the movement of high clouds, prevails over Texas, New Mexico, and adjoining States of the Southwest. This movement under favorable conditions was useful as a precept for a rain forecast in Mississippi Valley States.[10]

It is not surprising, therefore, that the free-air kite records should confirm the existence of this southwest current at levels much lower than those indicated by Ci. and other forms of high clouds. Two kite stations are available—Groesbeck, Tex., about 200 miles inland from the Gulf of Mexico, and Broken Arrow, Okla., about 300 miles farther inland in an almost direct north-south line with Groesbeck. Part of the data used have already been printed in WEATHER REVIEW SUPPLEMENT No. 20—An Aerological Survey of the United States (Tables 13a and 13d)—and the data necessary to bring the material down to date has been kindly supplied by the Aerological Section from manuscript reports. In SUPPLEMENT No. 20 the data are presented for each of 16 points of the compass. In order to reduce the labor of analyzing the whole mass of data for each direction I have selected a single pair of oppositely-directed winds for presentation, viz, southwest and northeast winds. And I have combined with those directions the data for the two immediately adjacent points of the compass, thus NNE. and ENE. have been combined with NE. in the one case and SSW. and WSW. with SW. in the other case. The percentage frequency of the winds up to 4 km. for NE. and SW. are given in the table below.

TABLE 2.—*Frequency in percentages of winds from the directions and at the levels named at the Kite stations of Groesbeck, Tex., and Broken Arrow, Okla.*

SPRING

Altitude above m. s. l. in m.	Groesbeck						Broken Arrow					
	141 (surf.)	1,000	1,500	2,000	3,000	4,000	233 (surf.)	1,000	1,500	2,000	3,000	4,000
Whole number of observations	493	459	404	348	190	44	430	422	378	328	151	28
NNE., NE., ENE.	14	10	7	5	4	0	14	12	9	8	5	0
SSW., SW., WSW.	21	34	41	48	60	50	18	35	45	51	47	36

SUMMER

Altitude above m. s. l. in m.	Groesbeck						Broken Arrow					
	141 (surf.)	1,000	1,500	2,000	3,000	4,000	233 (surf.)	1,000	1,500	2,000	3,000	4,000
Whole number of observations	419	377	317	262	114	33	321	313	275	239	129	30
NNE., NE., ENE.	5	6	5	4	5	9	9	8	6	6	3	0
SSW., SW., WSW.	48	56	57	52	42	27	32	51	56	57	53	57

[10] Cf. Weather forecasting in the United States, p. 287.

TABLE 2.—*Frequency in percentages of winds from the directions and at the levels named at the Kite stations of Groesbeck, Tex., and Broken Arrow, Okla.*—Continued

AUTUMN

Altitude above m. s. l. in m.	Groesbeck						Broken Arrow					
	141 (surf.)	1,000	1,500	2,000	3,000	4,000	233 (surf.)	1,000	1,500	2,000	3,000	4,000
Whole number of observations	496	454	394	376	236	80	385	372	329	279	157	51
NNE., NE., ENE.	19	20	15	9	7	9	18	15	12	5	4	2
SSW., SW., WSW.	18	29	33	35	39	46	21	38	45	52	55	48

WINTER

Altitude above m. s. l. in m.	Groesbeck						Broken Arrow					
	141 (surf.)	1,000	1,500	2,000	3,000	4,000	233 (surf.)	1,000	1,500	2,000	3,000	4,000
Whole number of observations	485	436	385	329	213	61	370	361	292	234	109	20
NNE., NE., ENE.	17	13	5	3	1	0	15	18	10	5	1	0
WSW., SW., WSW.	24	36	43	43	45	43	20	37	40	39	36	30

The outstanding feature of the above table is the great contrast between the frequency of southwest and northeast winds in all seasons and at both stations. There is no reversal in the ordinary meaning of that word, but rather the southwest current increases greatly in frequency in spring, reaches a maximum in summer, and diminishes somewhat in winter, but remains the dominant current even in winter. Northeast winds are most frequent in winter, but even then they are much less frequent than southwest winds.

Broken Arrow, being farther inland than Groesbeck, and consequently having more of a continental climate, shows more of the influence of the seasonal change in winds and temperature than does Groesbeck. In winter, for example, at the 2 km. level at Groesbeck 28 per cent of the winds are from the northwest and but 5 per cent from the southeast; at Broken Arrow the percentage of northwest winds is 31 against but 1 per cent from the southeast.

The percentage for summer for the 2 km. level are Groesbeck SE. 18, NW. 7, Broken Arrow SE. 8, NW. 5, values too small to be embraced under the term "monsoon" winds, although there is a sharp change in direction due to seasonal changes in temperature over the continent and adjacent water surfaces.